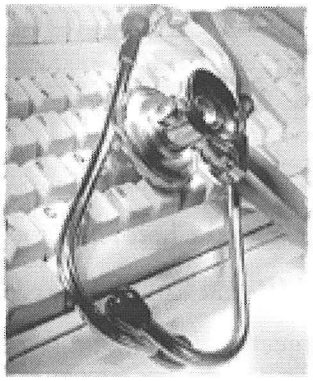
The Electronic Medical Record and Improving Health Care Delivery:

Achieving the promises, avoiding the pitfalls



"That it will ever come into general use, notwithstanding its value, is extremely doubtful because its beneficial application requires much time and gives a good bit of trouble, both to the patient and to the practitioner; because its hue and character are foreign and opposed to all our habits and associations..."

--from The London Times, 1834, on the newly-invented stethoscope

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INTERNAL MEDICINE GRAND ROUNDS
University of Texas Southwestern Medical Center

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This is to acknowledge that DuWayne Willett, MD has not disclosed any financial interests or other relationships with commercial concerns related directly or indirectly to this program. Dr. Willett will not be discussing off-label uses in his presentation.

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Interests:

- non-invasive cardiac imaging (echocardiography, nuclear cardiology)
- medical informatics, in particular:
    - workflow redesign for using an electronic medical record
    - clinical research informatics
    - decision support system design

CONTENTS:

1 Introduction

1.1 The "Healthcare IT Paradox" and Healthcare Information Systems Complexity

Healthcare delivery is an information-intense activity. Yet traditionally medical practices and health care organizations have lagged behind other industries in employing information systems technology—a situation that has been labeled the "healthcare IT paradox." For instance, even in 2003 fully computerized medical records are a rarity, with less than 10% of physician practices estimated to be using them. Physician order entry systems in hospitals—touted as an important way to reduce medication errors for hospitalized patients [1]—are currently estimated to be actively used today in only 1 to 3% of hospitals nationwide. [2]

The "as-is" information systems in healthcare organizations are marked by complexity. Typically a mix of paper and electronic data stores is used, both for medical records and for other data storage and retrieval needs. Similarly, a mix of manual and computer-based processes are employed in day-to-day work. A wide variety of internal and external personnel access this data and use these processes: office and hospital staff, nurses, physicians, pharmacists, billing office personnel, insurance company employees, benefits management administrators, and regulatory agency officials. Health care organizations have grown in size and are often distributed geographically over multiple sites, all needing access to the same data and running similar processes. As in many organizations, current healthcare processes have largely evolved over time through incremental ad hoc additions and modifications. Computer databases and computerized processes have frequently been overlaid on existing paper-based ones, complicating the job of the clinician seeking a comprehensive overview of their patient's data.

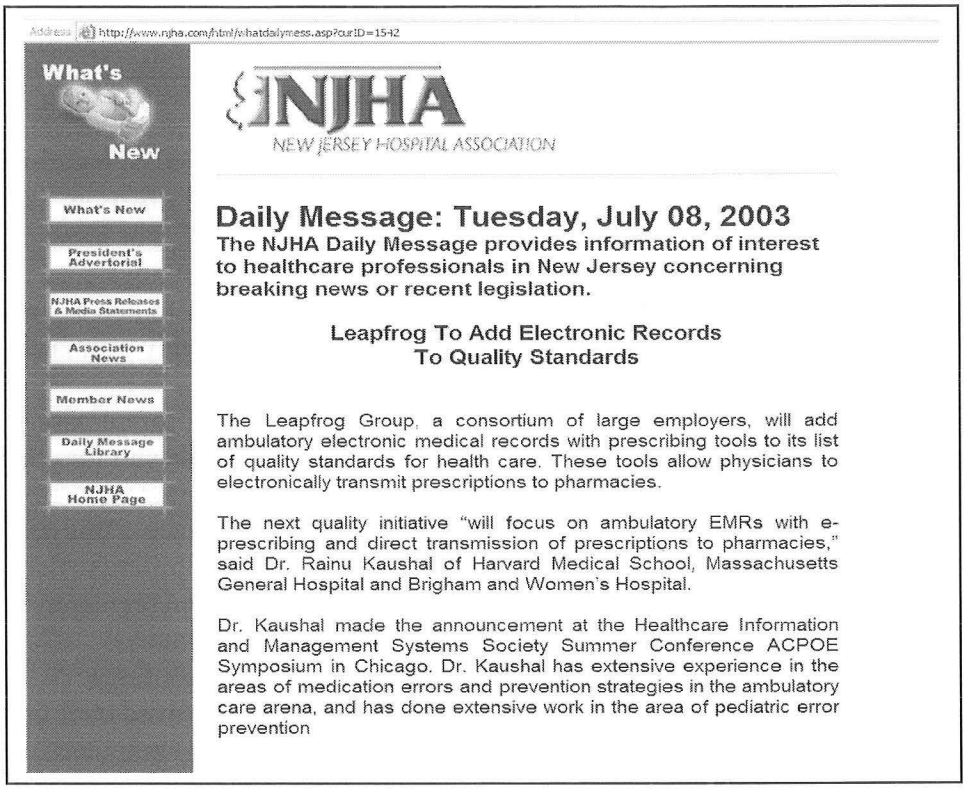
1.2 Current Challenges in Healthcare Delivery

Against this backdrop of increasing information systems and organizational complexity, the knowledge base for medical care continues to grow rapidly. New discoveries, new pharmaceuticals, new medical technologies, and new assessments of the effectiveness and interactions of these all constantly need to be assimilated for optimal quality. Concern has arisen regarding the safety level of the current healthcare system, particularly when compared with other highly technical and safety-critical fields such as air travel [3, 4].

Additionally, "customer service" is a relatively underdeveloped concept in many healthcare organizations [5]. Consumers who have learned from other industries what good customer service can be like are often highly frustrated in their dealings with the healthcare system. Finally, reimbursement rates for medical care delivery are under intense downward pressure in terms of payment per unit of service, as both governmental and private group purchasers of medical care have become increasingly larger, more knowledgeable and better managed.

Several pressures then exert themselves simultaneously on today's healthcare practice:

- Pressure to improve clinical quality
    - Leapfrog Group: evaluates hospitals in selected regions (including DFW), and publishes a scorecard on their web site (http://www.leapfroggroup.org/consumer_intro1.htm)
        - Critical care specialists
        - Procedure volume
        - **Inpatient Computerized Physician Order Entry (CPOE)**
        - Adding **ambulatory electronic record and prescribing** later in 2003



  - Institute of Medicine
    - The Computer-Based Patient Record: An Essential Technology for Health Care, Revised Edition, 1997 [6]
    - "To Err is Human," 1999 [3]
    - "Crossing the Quality Chasm," 2001 [7]
  - Government
    - State legislatures passing laws addressed at improving patient safety. [8, 9]
    - Federal government sponsoring inquiries, studies on patient safety

- Pressure to improve service quality
  - Patient expectations

    "If banks, airlines, maintenance companies, financial services, package delivery firms, and hotels treated their customers to the levels of waiting, unanswered questions, inconvenience, and obscure instruction that are the norm in health care, they would be unable to survive." [5]

- Pressure to contain costs

1.3 What's an Electronic Medical Record (EMR) got to do with it?

Thus healthcare organizations are challenged to improve the quality of healthcare delivery, better meet patient and other client service expectations, and reduce costs all at the same time. A key tool for achieving these aims can be process improvement projects, which have as their goals simultaneous improvement in costs, cycle time, quality, and customer service. [10, 11] In an information-driven field such as healthcare, such projects are largely concerned with "information systems" design, where the information system is broadly considered to consist of all manual and computer-based processes that handle data.

[12] An electronic medical record can play a key role in enabling process redesign not otherwise possible with a paper-only system.

- An EMR is cited in many clinical quality and service quality initiatives as a key enabler for improvement
    - From the Leapfrog Group's website, www.leapfroggroup.org :

      Computer Physician Order Entry (CPOE)
      "Prescriptions in hospitals should be computerized. With computerized prescription systems, doctors enter orders into a computer rather than writing them down on paper, and the prescription can be automatically checked against the patient's current information for potential mistakes or problems. For example, before the doctor can complete the prescription order, the computer would check to see if the new prescription would interact badly with another drug the patient is taking, or if the patient has a known allergy to it. This type of system also reduces mistakes that occur from misreading a doctor's handwriting. Studies show a computerized prescription system can reduce serious medication mistakes by up to 86 percent."

    - **The Computer-Based Patient Record: An Essential Technology for Health Care, Revised Edition (1997) [6]**
      Institute of Medicine (IOM)

      Physician Order Entry and Clinician Data Entry
      "Systems that physicians use routinely to enter orders, whether in the impatient setting or outpatient setting, can produce significant effects on quality and costs of care.
      In addition, when clinical data are entered and maintained by the clinicians responsible for care, the accuracy and quality of data are high. Very few commercial systems, however, are used by physicians to write all their orders. Human-computer interface issues and perceived benefit substantially affect the success of this function."

    - **To Err is Human,** Institute of Medicine, 1999 **[3]**

      "Experts estimate that as many as 98,000 people die in any given year from medical errors that occur in hospitals. That's more than die from motor vehicle accidents, breast cancer, or AIDS--three causes that receive far more public attention. Indeed, more people die annually from medication errors than from workplace injuries. Add the financial cost to the human tragedy, and medical error easily rises to the top ranks of urgent, widespread public problems.
      To Err Is Human asserts that the problem is not bad people in health care--it is that good people are working in bad systems that need to be made safer."

    - **Crossing the Quality Chasm** Institute of Medicine, 2001 **[7]**

      Making the Most of Technology
      "Health care organizations are only beginning to apply technological advances, the report says. For example, patient information typically is

dispersed in a collection of paper records that are often poorly organized, illegible, and not easy to retrieve. Sizeable benefits would be gained if certain types of data were automated routinely. For example, hospitals could significantly decrease serious medication errors by implementing a computerized medication order entry system, according to an article in *The Journal of the American Medical Association.*

To take advantage of information technology, a nationwide effort is needed to build a technology-based information infrastructure that would lead to **the elimination of most handwritten clinical data within the next 10 years**."

- Government getting involved
  - California law references CPOE by 2005:

    California Senate Bill 1875 requires health facilities and clinics (including general acute care hospitals, specialty hospitals, and surgical clinics, but excluding small and rural hospitals) to implement a formal plan to eliminate or substantially reduce medication-related errors by 2005. "This plan shall include technology implementation, such as, but not limited to, computerized physician order entry or other technology that, based upon independent, expert scientific advice and data, has been shown effective in eliminating or substantially reducing medication-related errors." [8]

- In a paper-based system clearly overwhelmed by advancing health care complexity, increasingly many feel that an EMR is the only viable alternative long-term.

  I am convinced that the medical revolution of our children's lifetimes will be the application of information technology to health care.

  --Tommy Thompson (Secretary, HHS), March 21, 2003

Assertions such as this need to be examined realistically, by appraising: (a) the extent of problems in the paper-based status quo, (b) what the reported benefits of an EMR are in published studies, and (c) the actual experiences of those attempting to implement an EMR over the past decade.

Before beginning that discussion, a glossary of various terms sometimes encountered in this literature is given below. For consistency, the bolded terms will be the preferred ones used here.

1.4 Glossary of terms

- **EMR: electronic medical record**
- EHR: electronic health record
- EPR: electronic patient record
- CPR: computerized patient record
- PHR: personal health record
- **CPOE: computerized physician (provider) order entry**

2 Problems with Current Paper-Based Chart and Processes

2.1 Medical chart problems

Chart unavailable or incomplete

"Tang et al [13] in the early 1990's found that pertinent patient data were unavailable in 81% of cases studied in an internal medicine clinic with a mean of 3.7 missing data items per case, even though the medical record itself was unavailable only 5% of the time....Although alternate professional data sources, the patient, and/or family members were used to successfully reconstruct history in 68% of instances of missing data items, the data need simply went unmet in the remaining 32%" [14]

Other reports have put the rate of missing charts during clinic visits as high as 30% in some settings. [15], cited in [14].

Difficult to locate relevant information

Clinicians have been described as employing at least four retrieval strategies to get relevant information out of medical records [16] [14] :

1. first-time reading, or getting a fast overview and understanding of a case
2. re-reading, or triggering a memory picture
3. searching for facts (targeted data retrieval)
4. problem solving

Strategy # 3 is often accomplished by thumbing through or flipping through a thick chart, leading to somewhat fortuitous (and often incomplete) location of relevant data. Nonetheless, in a Swedish study [16], experienced physicians were quite adept at manipulating even large paper records, and reported reasonably good satisfaction with them. The authors inferred implications for design of human-computer interfaces to be used by physicians in information retrieval:

> (a) "Expose lots of information to the user, but with a high degree of positional and textural structure. Enable information items to attract the reader's attention even if it is not asked for.
>
> (b) Orientation and navigation is essential. Attention must be paid to graphical and textural features of the text presented. These should be controlled to indicate logical relations in order to enable effective limitation of search space. Make it possible for the user to use positional clues in re-reading and in search. It should be effortless to go both forwards and backwards and also to trace a referral form and then return to the page being read.
>
> (c) Let the user see the whole record in the sense that what is there is all there is. Thus make it possible to reflect upon what is not there..."

Chart entries illegible

Illegible prescriptions and other chart entries are conceded by everyone to be a problem, hindering the ability of third parties – even other physicians – from understanding the historical, diagnostic, and treatment information (including orders) intended to be conveyed. Patient injuries have resulted, and lawsuits won. Washington State and Florida now have laws mandating legible prescriptions, including printing out in full certain sections of each prescription. [9]

2.2 Process problems

Process problems are now thought to be a major cause of medical errors [3, 7] as well as poor service quality and wasteful inefficiencies. They can be of various types (list not exhaustive):

Medical errors due to missing, incomplete or inaccurate information

Examples include prescribing a medication to which a patient is allergic, failure to adjust dosing for an unknown elevated creatinine, and so on.

Things "falling through the cracks"

Lost lab or procedure results, lost telephone message forms, un-rescheduled appointments, consultations requested but never scheduled, and so forth.

"Service stinks"

Unanswered telephone calls, unreturned telephone calls, difficult-to-understand instructions, unpredictable appointment times or sudden provider cancellations.

High costs

These can take several forms, among them:

Hidden costs

- Avoidable work, such as handling a follow-up call from a pharmacy because the initial prescription renewal request was not handled in a timely way.
- Rework, such as re-transcribing illegible information from one form to another.

Redundant costs

- Ordering and performing a test again, because the result of the first test (or even knowledge that is was done) are not available
- Transcribing the same data elements (e.g. diagnosis, patient name, ordering physician) onto multiple separate forms, each for a single test type.
- Recording test results in multiple systems.
- Re-keying data from one computer system to another, or typing the same patient information into multiple systems.
- Re-recording and re-dictating an unchanged Problem List or Medication List with every visit to the same or new clinic within a group practice.

Other "non-value-added" activities

- Routing work among 2 or more parties, without a clear rationale for each such "handoff."

3 Rationale for Adopting an EMR and Computerized Provider Order Entry

The rationales given by proponents of an EMR closely match the list of problems just described.

3.1 Improve medical chart information quality & patient safety

Several studies now have shown significant positive effects of an EMR with Computerized Provider Order Entry (CPOE) on:

- Reducing medication errors and adverse drug reactions
- Improving appropriate antibiotic selection
- Reducing redundant test ordering

Table 3. Studies of Computerized Physician Order Entry (CPOE) With Clinical Decision Support Systems (CDSSs)

Source	Study Description	Study Design	Study Outcomes	Results
Overhage et al,[24] 1997	Impact of faculty and physician reminders (using CPOE) on corollary orders for 2181 adult inpatients in a general medical ward at a public teaching hospital affiliated with the Indiana University School of Medicine	Level 1 (RCT with physicians randomized to receive reminders or not)	Level 2 and 3 (errors of omission in corollary orders)	25% Improvement in ordering of corollary medications by faculty and residents ($P<.001$)
Bates et al,[25] 1998	CPOE with CDSSs for 6771 adult inpatients on medical, surgical, and intensive care wards at BWH, a tertiary care center affiliated with Harvard University	Levels 2 and 3 (2 study designs)	Level 1 (ADE rates) and level 2 (serious medication errors)	55% Decrease in nonintercepted serious medication errors ($P = .37$) and 17% decrease in preventable ADEs ($P = .37$)
Bates et al,[26] 1999	CPOE with CDSSs for 1817 adult inpatients in 3 medical units at BWH	Level 3 (retrospective time series)	Level 1 (ADEs) and level 2 (main outcome measure was medication errors)	81% Decrease in medication errors ($P<.001$) and 86% decrease in nonintercepted serious medication errors ($P<.001$)
Teich et al,[27] 2000	CPOE with CDSSs for all adult inpatients at BWH	Level 3 (retrospective before-after analysis)	Levels 2 and 3 (changes in 5 prescribing practices)	Improvement in 5 prescribing practices ($P<.001$ for each of the 5 comparisons)
Chertow et al,[28] 2001	CPOE with a CDSS to adjust drug dose and frequency in 7490 adult inpatients with renal insufficiency at BWH	Level 1 (RCT with a crossover design)	Level 2 (inappropriate drug dose and frequency)	13% Decrease in inappropriate dose ($P<.001$) and 24% decrease in inappropriate frequency ($P<.001$)

Abbreviations: ADE, adverse drug event; BWH, Brigham and Women's Hospital; RCT, randomized controlled trial.

Ref: [17]

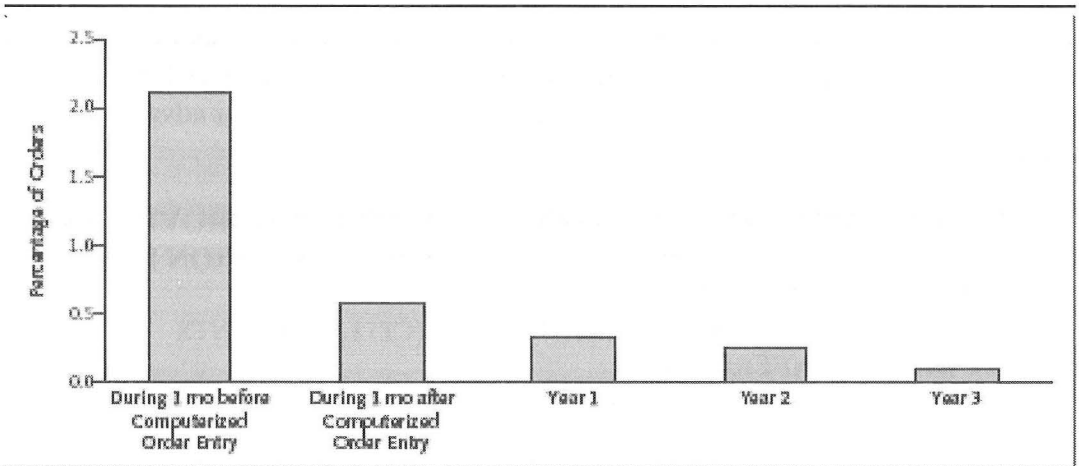


Figure 2. **Percentage of Medication Orders with Doses Exceeding the Maximum.**

Data are the percentage of orders for doses exceeding the medication-specific recommended maximal dose according to year, after the implementation of a computerized system for order entry by physicians.[29] The application suggested a default dose and displayed only potentially appropriate options, but it did not check for overly high doses. Even so, the percentage of orders exceeding the recommended safe maximum fell by more than 80 percent over a three-year period.

Ref: [18]

3.2 Improve patient service quality

Research has been done on how waiting times affect patient satisfaction, along with the impact of other related factors (where the patient waits, what they have to do while they wait). In one study, the most important waiting time predictor of patient satisfaction was total time waiting to see the physician (in waiting room and in treatment room). Having things to do while in the waiting room, and informing patients how long they will have to wait improved their satisfaction [19]. Some have suggested providing the ability for patients to access and enter patient health data into a patient-maintained section of the EMR from a computer in the waiting room, although privacy issues clearly arise.

Another offering being pursued is patient access to portions of their medical chart online, e.g. via the Internet. When asked about specific aspects of such an accessible online Personal Health Record, according to a Harris Poll, consumers react favorably:

- 83% of healthcare consumers want lab tests available online
- 69% want online charts for managing chronic conditions
- 80% want to receive personalized medical information online from their doctor after an office visit

Of interest, improved service quality also correlates with physician satisfaction, and generally lowers costs of care [5]. Little data currently exists on the effects of commercially-available EMRs on specific measures of service quality, such as appointment access, rates of notification of patients of test results, lag times for providing patients their results or responding to messages, etc.

3.3 Decrease costs

Although EMR projects are expensive – whether purchased or homegrown – evidence for their beneficial effect on reducing costs has been reported. The home-grown EMR at Brigham and Women's Hospital reportedly cost ~ $1.9 million to develop and ~ $500,000/year to run, and is estimated to save $5-10 million annually for the hospital.

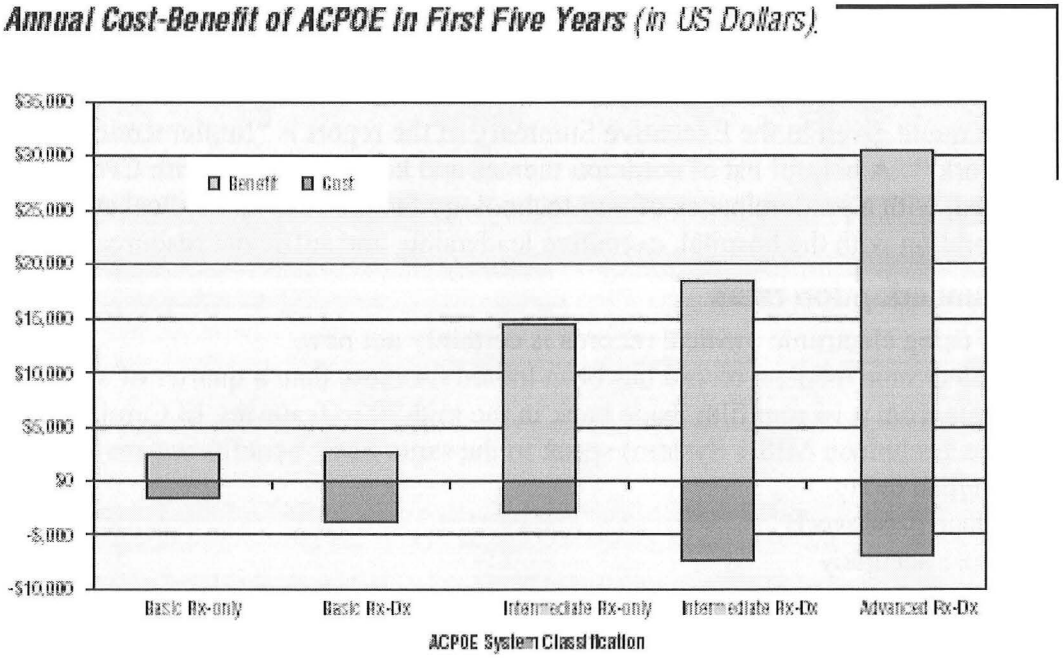
A model developed by the Center for Information Technology Leadership (see following) suggests that implementing a CPOE pays off, and more so for more advanced systems, despite their greater up-front cost (~$29,000 per provider implementation cost for advanced systems!).[20]

NEW RESEARCH SHOWS AMBULATORY COMPUTERIZED PROVIDER ORDER ENTRY (ACPOE) WOULD PREVENT MILLIONS OF MEDICATION ERRORS AND SAVE BILLIONS OF DOLLARS
--THE CENTER FOR INFORMATION TECHNOLOGY (CITL) PRESENTS FINDINGS AT HIMSS CONFERENCE—
SAN DIEGO – (February 10, 2003) - The Center for Information Technology Leadership (CITL), chartered by Partners HealthCare in Boston and supported by the Healthcare Information and Management Systems Society (HIMSS), today released findings showing that national adoption of Ambulatory Computerized Provider Order Entry (ACPOE) would prevent more than 2 million medication errors and save about $44 billion annually. The results were presented at the 2003 Annual HIMSS Conference and Exhibition in San Diego.
"Our findings demonstrate the benefits of implementing this technology in an outpatient setting," said Blackford Middleton, M.D. and chair of CITL. "Many in the industry suspected that the costs would outweigh the benefits for ACPOE. However, we not only disprove that view, but also demonstrate substantial clinical benefits of this extremely valuable technology." [21]

ACPOE System Classification.

	1: Basic Rx-only	2: Basic Rx-Dx	3: Intermediate Rx-only	4: Intermediate Rx-Dx	5: Advanced Rx-Dx
Medication Order Entry	Record prescription. Print prescription for patient.		Same as Basic Rx plus fax or email to pharmacy or pharmacy benefit manager.	Same as Intermediate Rx-only.	Same as Intermediate Rx-only, plus electronic data interchange (EDI).
Medication Decision Support	Passive (user-initiated) references like click-through to electronic medical textbook. Not order or patient-specific.		Active (system-initiated) order-specific decision support. • Simple interaction checks (drug-drug, drug-allergy) • Default doses and dose range checks • Cost data • Order sets		Same as Intermediate Rx-only, plus: • Complex interaction checks (drug-drug, drug-allergy, drug-disease) • Drug recommendations using calculated or inferred knowledge (drug choice guided by lab results, drug dosing) • Corollary orders
Diagnostic Order Entry	None	Record order. Print order for patient.	None	Same as Basic Rx-Dx plus fax or email to lab or radiology. With or without result reporting.	Same as Intermediate Rx-Dx, plus EDI. With result reporting.
Diagnostic Decision Support		Passive references like click-through to lab manual. Not order or patient-specific.		Active order-specific decision support such as cost data, order sets, or pre-test preparation instructions.	Same as Intermediate Rx-Dx, plus: • Order and test recommendations using extensive patient information, including calculated or inferred knowledge • Corollary orders • Preventive screenings and alerts

Reference for both graphs: [20]



4 Real-World EMR/CPOE Projects

Given the patient-care and financial stakes involved, there is considerable interest in the success or failure of EMR projects around the country. As one might expect, there appears to be a strong "publication bias" in this field, with successes much more likely to be described in published peer-reviewed reports than failures, both types of reports can be found, particularly if news media and websites are also searched.

4.1 Generalizability of early success reports

Despite the remarkably favorable measured effects in the most well-done EMR studies [18, 22-25] concern has been raised about the representativeness of these efforts. In particular, the systems and institutions reporting had the following characteristics, by and large:

- Academic medical centers
- "Home-grown" EMR systems
- Inpatient setting
- Resident physicians doing the majority of order entry
- Very small number of institutions and systems overall

By way of contrast, 89% of all hospitals in the U.S. are community hospitals, with predominantly independent physicians (not hospital employees). Additionally, the vast majority of hospitals will purchase their EMR systems from a commercial vendor, as the prospect of building one's own is daunting and fraught with difficulty and risk [26].

In an attempt to fill this void, the California HealthCare Foundation's Quality Initiative and the First Consulting Group co-sponsored an extensive study of 10 community hospitals who have been early adopters of CPOE, with reasonable success. [27] All hospitals experienced some difficulties during implementation, and usually pushed towards universal adoption of CPOE in stages. The initial goal of the research was to find 10 hospitals with 80% of orders entered by physicians, but this standard had to be relaxed considerably. One hospital had 99% of med orders entered by physicians (attendings and some residents), the remainder varied from ~ 10-60% MD entry for all orders. The single sidebar quote given in the Executive Summary of the report is "Implementing CPOE is hard work." A helpful list of common themes and keys to success with CPOE is provided, with a predominance of non-technology factors such as medical staff collaboration with the hospital, executive leadership, and sufficient resources.

4.2 Actual adoption rates

The notion of using electronic medical records is certainly not new.

> "The electronic medical record has been touted for more than a quarter of a century. Excerpts from a 16 mm film made back in the mid-70's (featuring El Camino [Hospital] and the Technicon MIS 1 System) speak to the same EMR benefits we are still trying to accomplish today:
> - Reduce paperwork
> - Ensure accuracy
> - Eliminate manual charting
> - No lost or mis-filed reports
> - Enhance patient care" [28]

Nonetheless, despite national calls for more widespread adoption of an EMR [3, 6, 7, 15], actual rates of full-implementation are low. While such activities as medical billing and lab results

retrieval have long been widely computerized, online clinical documentation and physician order entry have not. A study in the late 1990's found that < 2% of U.S hospital had CPOE available and required its use by physicians. [29] This year, two consultants who studied the issue estimated that "fewer than 1 percent of hospitals nationwide have anything like what they would call a true CPOE system (although 3 percent report having something up and running)." [2]

Controversy exists over whether the U.S. is on the cusp of much more widespread adoption of electronic medical records. At a recent annual conference dedicated to promoting the use of electronic records (http://www.medrecinst.com/conferences/tepr/2003/index.shtml), reportedly there was a sense that a critical mass of system improvements and other forces is now present, making the "tipping point" nigh for much wider use of EMRs. [30] Others remain waiting to be convinced: an attendee at the same conference (TEPR 2003) was quoted as saying: "20 years ago, people said we'd adopt these tools within five years. And the same thing happened 15 years ago. And 10 years ago....So, should I say, these tools will be adopted within 5 years?" [2]

4.3 Successful EMR Projects

Many of the most well-done and most-quoted studies of EMR-related outcomes have come out of a relatively few institutions who've successfully pioneered enterprise EMRs. Each reports having suffered some setbacks during their road to widespread and successful use. The following list is representative, but not exhaustive:

- Brigham and Women's Hospital [22, 23]
- Indiana University: Regenstrief Institute [31]
- LDS Hospital/Univ of Utah [32]
- VA: VistA/CPRS [33, 34]: The VA EMR system is notable in a number of respects:
    - It is deployed nationally, at 163 hospitals as well as additional facilities
    - Use is high. In September 2002, 90.6% of all inpatient and outpatient pharmacy orders nationwide were entered by providers. [33]
    - The software is in the public domain, spawning emerging interest in an "Open Source" software movement in healthcare [35]
    - Anecdotally (from chance conversations with a few UT Southwestern housestaff and fellows), the CPRS version of the system appears to be fairly straightforward to use. The few housestaff I've talked to strongly prefer using this EMR to the paper-based chart at our non-VA teaching hospital.

While general characterizations are difficult, and each successful project is unique, each of the above projects grew or was rolled-out incrementally. Additionally, clinicians participated actively in the design and/or configuration of the software modules used by physicians. These strategies are being emulated by several of the large commercial vendors of EMR systems. Several authors comment on the importance of active physician participation in the design of order sets: specialty-specific (sometimes physician-specific) common groups of orders. Such order sets appear to offer significant time-savings compared with individual orders, and to be a key feature in making CPOE work for physicians.

4.4 Problematic &/or Failed EMR Projects

Information about these is generally most available outside the peer-reviewed literature, e.g. in trade publications, the general news media, personal communications, or trusted web sites.

Cedars-Sinai:

The most publicized recent example was the decision to halt inpatient CPOE in the home-grown EMR rolled-out at Cedars-Sinai Hospital in Los Angeles in the fall of 2002. Perhaps because of recent calls for widespread adoption of CPOE, this project failure became national news in healthcare circles.

Doctors pull plug on paperless system

California's Cedars-Sinai turns off its computerized physician order entry system after physicians revolt, demonstrating that implementing new technology is easier said than done.

By Tyler Chin, *AMNews* staff. Feb. 17, 2003.

Information technology is often touted as the cure for all that ails the delivery of quality medicine, but some physicians say this cure can be worse than the disease.

Cedars-Sinai Medical Center in Los Angeles turned off its computerized physician order entry system in January, after hundreds of physicians complained that rather than speeding up and improving patient care, it actually slowed down the process of filling their orders -- assuming those orders didn't get lost in the system.

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"I'm not opposed to change ... but it's got to be new and better," said Dudley Danoff, MD, a urologic surgeon who helped organize physician opposition. "This was new but certainly not better" than paper.

Cedars-Sinai's decision was extraordinary but not unique. David Classen, MD, of First Consulting Group, says he knows of at least six other hospitals that have pulled paperless systems in the face of physician resistance and other problems.

Successful implementations of computerized order entry involve physicians in all phases.

The issue, Dr. Classen said, is not necessarily one of the quality of the technology. The success of paperless order entry and electronic medical record systems has to do with how they're implemented as much as what is being used, experts say.

In Cedars-Sinai's case, the hospital believed that by working with a 40-physician medical executive committee, it had sufficiently involved physicians in the design and implementation process. But rank-and-file doctors said the committee did not represent their interests.

Reference: [36]

CHCS (DOD)

The Department of Defense—starting from the same code base as the VA's original "DHCP" system—initiated a $2 billion project to develop an integrated electronic medical record system across all branches of the military. Termed CHCS (for Composite Health Care System), the system was intended to use CPOE. Meaningful clinician involvement in the project was initiated late, after the character-based screen designs for their use were already in place. Alpha-testing was done at Tripler Army Hospital in Honolulu, a teaching hospital. On a site visit in 1992, the housestaff entering the orders (all were junior military officers) recounted that they had been given orders not to complain about the system, and some had been disciplined when they did. Even physician EMR enthusiasts at Beta sites within the DOD found the software unworkable in daily practice. Despite the presumptive ability to give military orders to active duty military physicians to use CHCS (and in part due to concerns about a negative effect on MD retention), the CPOE portion of the system was withdrawn, and never deployed as planned. 10 years later, in the winter of 2002, a revamped product ("CHCS II") was finally approved for roll out on a limited basis, with plans for DOD-wide adoption eventually :

> Larry Albert, health care practice leader and senior vice president at Integic, said CHCS I was a "hospital-centric" system that did not enable physicians to share information, whereas CHCS II is "patient-centric."
>
> Albert said the plan is to roll out the system at four more hospitals in the coming year, before launching a "more aggressive worldwide rollout" in late 2003.
>
> Pace said CHCS II has cost $275 million so far, and the 18-year life cycle funding for the system is estimated to be just less than $4 billion. [37]

Very little other published information about the debacle with the initial CHCS project appears to be readily retrievable. A website devoted to information about the VA's VistA/CPRS program comments obliquely on CHCS's troubles:

"…until recently CHCS's development was brought to a complete stop by political opposition within the DoD. VA and DoD have been instructed for years to improve the sharing of medical information between the two systems, but have nevertheless for political reasons managed to make little progress toward bringing the two dialects back together." [34], accessed in 2003

Family Practice programs

"Termination of a Contract to Implement an Enterprise Electronic Medical Record System" [38]

- "In August 1998, United Health Services initiated a project to implement an enterprise EMR…..In February 2000, the enterprise EMR project was terminated"
- "Although we could find in the literature only two reports of failures, a survey of family practice residencies revealed ten programs in which an EMR had been used but discontinued."
- "…the integrator failed to recognize the extent of the work redesign efforts needed by the rest of the enterprise to enable the implementation of the technology.
- Senior management failed to recognize how the project is merely an enabling technology for fundamentally reorganizing the way we do business…"

Other programs

University of Virginia

Implementation of a commercial inpatient EMR at this academic medical center in the early 1990's was very rocky, with the housestaff ultimately threatening to strike over mandated use of the EMR. However, the system was adapted with much housestaff and attending input, and eventually achieved acceptance [39, 40]

At another eastern academic medical center, an EMR rollout (commercial product) in the early 1990's was halted after the initial specialty clinic was piloted with it. "It was very clear this was not going to work for us" reports an EMR physician advocate at that center (personal communication). 10 years later, the medical center is now beginning to look again at installing a new EMR campus-wide.

4.5 Kaiser-Permanente, and the selection of an EMR vendor

On February 4, 2003, the Wall Street Journal gave this report:

> "In what may be the most ambitious move yet toward electronic medical records, Kaiser Permanente, the nation's largest nonprofit health-maintenance organization, Tuesday will announce plans to spend $1.8 billion to automate its patient files. Kaiser, with 8.4 million members in nine states, said its goal is to have the automated records up and running in three years. With such a system, the HMO would make portions of each patient's records available online to members, who would be able to check recent medical-test results, see their complete immunization history and review their current medications, among other things.
>
> To accomplish the electronic shift, Kaiser will purchase a system from Epic Systems Corp., a Madison, Wis., software concern, and abandon a decade-long effort to develop such a system itself." [41]

This announcement highlights several issues:

1. The difficulty of developing an enterprise-scale electronic medical record system. Kaiser's IT department is well-respected in health care circles, and has contributed much to the field. Nonetheless, Kaiser management believed the only way to proceed on the time scale they desired was to purchase a complete system, and not "reinvent the wheel" by expanding their own development work.
2. It's been said that contracts between a medical practice or healthcare system and an EMR vendor are more like a marriage than a purchase. The financial commitment is large, but importantly one must contemplate a long-term relationship because electronic medical records currently cannot easily be transported from one system to another.
3. As a corollary, an assessment of EMR vendor financial stability and long-term viability is an important part of vendor selection.

5 Pitfalls Encountered in EMR/CPOE Projects

5.1 MD resistance to change

Introducing an EMR into a healthcare setting is clearly a major change. While resistance to change (or especially to being changed) is a universal human characteristic, the level of physician reluctance or even frank revolt in institutions experiencing failed EMR implementations raises the importance of understanding the causes of this "recalcitrance." In particular, it is crucial to distinguish among:
(a) general resistance to any change vs.
(b) resistance to new technology in medicine (technophobia) vs.
(c) reluctance to adopt a given EMR in a certain setting because it fails to effectively meet clinician needs and/or doesn't fit into the way clinicians work.

My (somewhat biased) take is that item (c) is by far the dominant factor. Furthermore, the system user interfaces (while not perfect) have gotten increasingly better-designed over the last few years. In my view, by far the single largest impediment today to effectively deploying an EMR in a practice or healthcare system is an inadequate "fit" between the EMR and clinical workflows. Those that succeed almost universally report that adaptation needs to occur on both sides [42]:

- Clinical workflows must be thought through, and if necessary redesigned to fit with the EMR. The ability to handle unusual or exceptional situations is a time-consuming but critical part of this analysis.
- The EMR will need to change as it is employed in a greater number and more diverse environments, and as its limitations become evident in daily practice. The ability to locally configure an EMR is a must, as is the responsiveness of the EMR vendor in modifying the software itself to meet prioritized clinician needs.

This mutual adaptation is not a one-time thing, but an ongoing process of revision and improvement.

5.2 MD technophobia?

This reason was offered frequently in the 1990's to explain physician reluctance. Closer examination belies this as a major cause, however. Physicians adopt gadgets in their practices and at home at fairly prodigious rates. Even in the early 1990's physicians tended to be among early purchasers of home computers (survey by the author of DOD physicians, unpublished data). Home computer ownership now is near-ubiquitous. PDA and advanced paging and cell phone use are common among today's physicians. Over 90% of all physicians use the Internet. In many specialties, computer-based imaging and other medical equipment are used daily by clinicians. Many physicians in hospitals and large group practices willingly look up lab values online. New physicians now entering the workforce all used computers extensively in college and medical school; some in fact may have never used an actual typewriter. John Glaser, CIO of Partners Healthcare in Boston puts it this way:

> "People paint doctors as technophobes. That's just not true. But they do want to know the value. You have to a pretty good case for why you're going to bother with this."[43]

5.3 System factors:

A more profitable approach is to look at any mismatch between what a given EMR offers and what clinicians need in a given setting. Significant variation in clinician needs can be found between clinic and hospital, OR and ER, specialist and generalist, etc. Some system factors recur in most settings however, particularly response time and user interface design.

Speed (response time)

Clinicians would of course like instantaneous response time, all the time. However there does appear to be a threshold of computer response time (to update the screen in response to a command), beyond which physician complaints rise rapidly, and use declines. One study put this as short as 0.7 seconds! A current practical assessment of this threshold is ~ 2 seconds (John Halamka, CareGroup, Boston).

User interface design

Early EMRs were developed with character-based user interfaces, as they pre-dated the widespread adoption of the Macintosh and Windows style of graphical user interface ("WIMP" – Windows, Icons, Menus, Pointer). Systems than conform to expected behavior of these GUIs – by adhering to the Microsoft Office-style menu conventions, for instance – are easiest for clinicians to understand and use. The other widely-recognizable user interface is the Web browser, so that Web-style navigation aids can be effective.

On a more sophisticated level are design decisions for which information to display to the clinician on each screen, and what the navigation flow among screens should be like. Experts in the field of Human-Computer Interfaces (HCI) and intense clinician involvement during development can help result in interfaces that better meet the task needs of physicians, nurses and other health care personnel.

5.4 Clinician workflow effects

Building a computer system with fast response times and an easily-navigable user interface is important—even mandatory—but this is far from the whole story. For developers, the level of difficulty increases markedly as one moves from single-user applications to computer systems designed to support collaborative or cooperative work. The theoretic models and practical examples are less well-established for the field of "Groupware" or "computer-supported cooperative work (CSCW)" than for single-user software application development, which is challenging enough. Advances in understanding of CSCW have largely gone unrecognized in the medical informatics community. Fortunately this is changing as appreciation grows of the crucial nature of an EMR's effects on clinical workflow among members of a healthcare team.

A group of Scottish researchers working in the CSCW field performed an ethnographic study of the effects of collaborative work in an inpatient medical/psychiatric facility treating patients admitted with overdoses. Their abstract is cautionary:

"The introduction of the electronic medical record (EMR) is widely seen by healthcare policy makers and service managers alike as a key step in the achievement of more efficient and integrated healthcare services. However, our study of inter-service work practices reveals important discrepancies between the presumptions of the role of the EMR in achieving service integration and the ways in which medical workers actually use and communicate patient information. These lead us to doubt that technologies like the EMR can deliver their promised benefits unless there is a better understanding of the work they are intended to support and the processes used in its development and deployment become significantly more user-led." [44]

Some authors comment on the relatively increased difficulty of implementing an EMR in the hospital, with generally much smoother sailing in the ambulatory care setting. One possible reason for this is the larger number of health care worker roles and consequently a more complex mix of collaborative work occurring in an inpatient setting as compared with an ambulatory clinic.

6 Processes and Workflow: Harvesting the promises of an EMR

6.1 Process/workflow definition

"...a collection of interrelated work tasks, initiated in response to an event, that achieves a specific result for the customer of the process" [45]

6.2 Importance of processes

Where do processes fit?

- Mission, strategy and goals
  - Describes the enterprise's markets or customers, their services, how they will differentiate themselves, and performance targets
- Processes
  - Businesses organize people, resources, and activities into ***processes*** which deliver value to external or internal customers, in keeping with the mission

Computer system

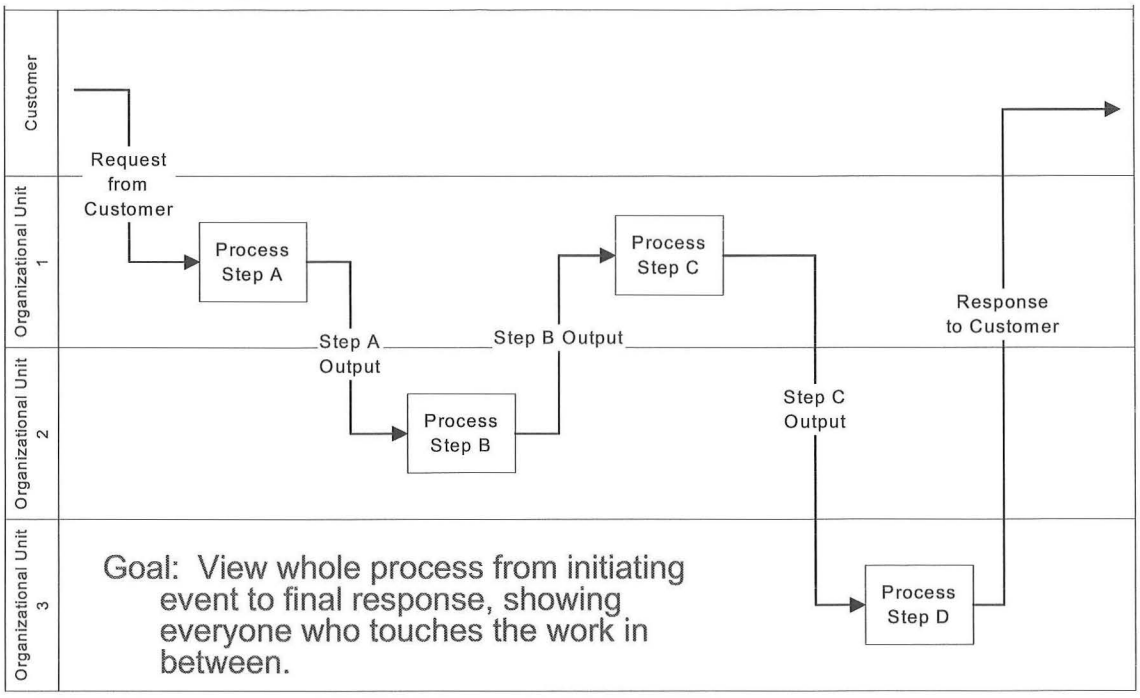
- User Interface
  - Mechanisms by which people or other systems interact with an information system
- Application Logic
  - "Transactions" containing logic to enforce business rules and maintain data integrity
- Data Management
  - Databases maintain records of people, things, events, etc. needed by the business

Processes

- How "the work gets done"
- The "missing link":
  - Organization goals → Processes → Individual job activities
- Why map processes?
  - Everyone can see whole start-to-finish workflow:
    - "why are we doing this?" "How do we get there?"
  - Can evaluate alternative "routes" or workflows
  - Clarifies roles: "who does what"

- ***Two assertions:***
  1. ***ALL Electronic Medical Record systems require clinical workflow redesign***
  2. ***The barriers to successfully implementing an EMR are primarily the effects on workflow, not the technology itself***

6.3 Mapping processes



Basic Process Measures

- Time
  - Cycle Time (start-to-end)
  - Throughput (# instances/unit of time)
- Cost
  - Overall process cost to take one unit of work from start to finish
  - Cost of each process step
- Quality
  - Defect-free rate of whole process (start-to-finish)

6.4 Role of process redesign in implementing an EMR

Core tenets of process redesign

- ❑ rethinking an organization in terms of its key ***processes***, rather than its organizational units
- ❑ focusing on those processes that directly impact the customer (external or internal)
- ❑ cross-functional process redesign teams, made up of people who actually work within the processes, in addition to technical people
- ❑ ***simplifying and streamlining processes*** during redesign → significant **improvements in cycle time, quality, and costs**--and ultimately customer satisfaction
- ❑ technology and information systems as a prime **enabler** of the process redesign effort
- ❑ central role for **measurement** of an organization's key processes

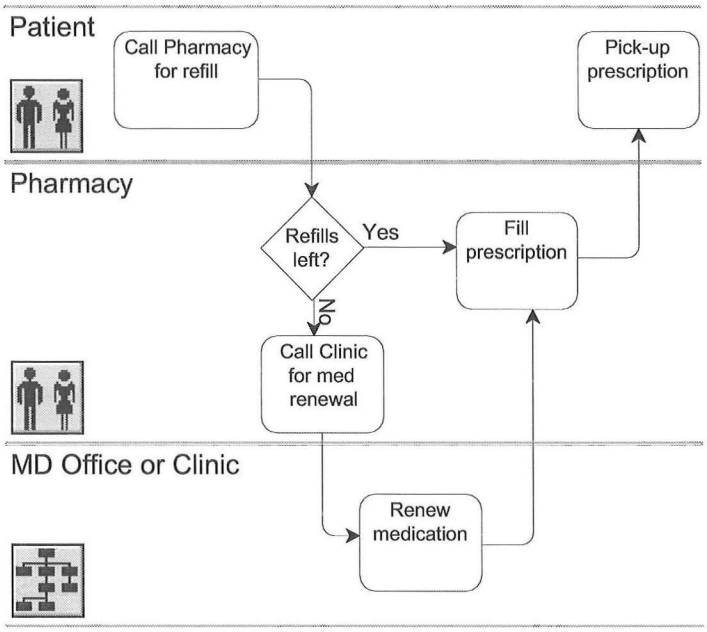
Role of EMR in Process Redesign

- Create information once, retrieve many times
  - Data consistency
  - Work reduction
- Networked availability of information
  - Avoid moving paper around
  - Avoid waiting for paper (Inbox & Outbox time)
  - Enable parallel flows of work
- Simpler processes
  - More value added at each step
  - Fewer "handoffs"—reduction in errors, lost work, rework
  - More training required for personnel
- Very low information loss rates between steps: automated workflow
- Real-time decision support & feedback
  - (e.g. drug – allergy checking in virtually all EMRs)

6.5 Example: "Renew a prescription"

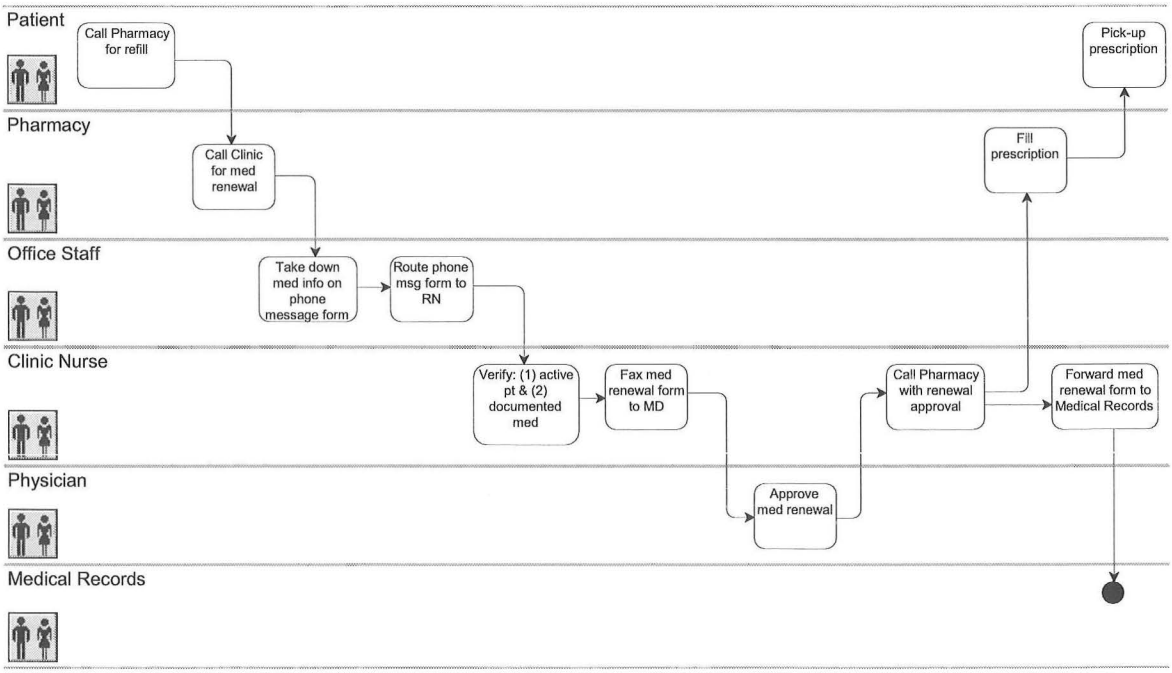
Refill Prescription process - patient view:

From the patient's and pharmacist's perspective, how we "Renew medication" is not their direct concern. They basically expect from us: (a) rapid turnaround time and (b) no lost messages.



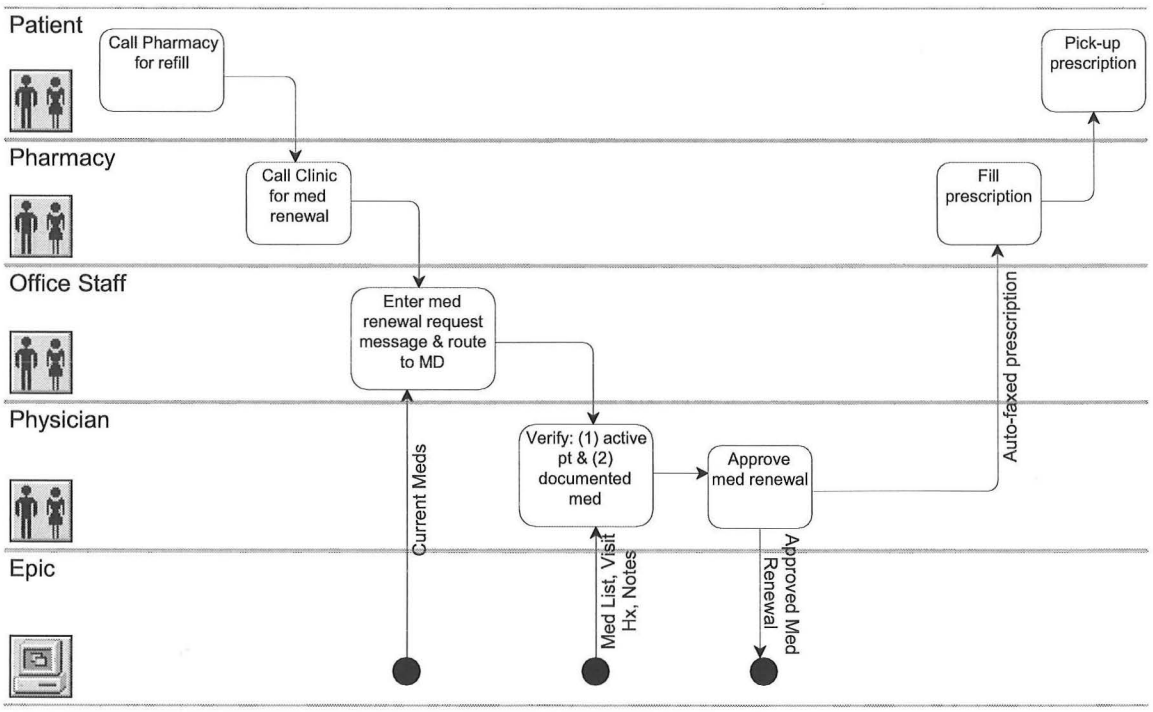
Refill Prescription process - paper-based process:

4 different staff members handle each Rx request we receive, with 4 "handoffs," each of which has an opportunity for delay or a lost message. Duplicate paperwork is created when a message is faxed to the MD and again when the MD faxes the authorization back. This is a lengthy, fairly costly process.



The cost of handling one refill can be estimated by taking an average time for each task multiplied by the fully-burdened expense for the worker accomplishing each task (and any supplies, which would be minimal), then summing up the costs of all process steps.

Refill Prescription process: EMR-based process, with autofax:



Now there are only two internal roles handling the work (down from 4), there is only one handoff (from office staff to Physician), which occurs essentially immediately via electronic messaging. The MD receives the electronic chart automatically with the medication renewal request, enabling a rapid chart review (e.g. of med list, last note), if desired.

When completed, the MD signs the Rx, which is then automatically faxed to the pharmacy for preparation and patient pick-up.

Compared with the paper-based process, this workflow is:

- *Faster*: quicker delivery of new Rx to pharmacy
  The chief factor determining cycle time here will be the time intervals at which the MD checks their EMR message list--but this is a factor with paper messages in an In-Box as well.
- *Higher quality*: less opportunity for lost forms, delayed tasks leading to repeat calls by pharmacy, etc
- *Lower cost*: The MD work time is lower, the RN and Medical Records personnel work time has been eliminated. (Note an RN could serve in the "Office Staff" role for this process if desired – but both an RN and a separate Office Staff member are not needed for the routine cases).

6.6 Measuring processes—relationship to process improvement

Processes are the physiology (or pathophysiology) of an organization, in contrast to the organizational chart "anatomy." In our clinical work, we track measures of patients' physiologic parameters for adverse trends (vital signs, O2 sat monitor, etc), in order to detect emerging problems and intervene in a timely way, to help avert crises.

Workflow processes can be similarly monitored. Key measures (cycle time, defect rate, cost, patient/customer satisfaction) can be selected, and trends monitored. Out-of-range "vitals" or emerging trends can be selected for analysis and intervention, typically a joint process improvement project, involving those who carry out the various process steps.

7 Conclusions

- Processes are the key to collaboratively accomplishing our work goals in an effective manner

- An EMR will change our processes/workflow (and vice versa). That's the hard part, but affords an opportunity to streamline our work, and improve patient service. The good news is that as physicians and internists, we're used to thinking about (bodily) systems and (metabolic) pathways: workflow mapping and redesign are quickly recognizable and understandable to us.

- Although EMRs have had a spotty history, the timing for implementing one now is good:
    - The EMRs are significantly better than even 3-5 years ago. Not perfect, but the best current ones appear able to work in most environments.
    - Best estimates are that EMRs are cost-effective for practices with 5 physicians or greater, but that smaller groups and solo practices won't recoup the cost of the technology.

- (Opinion) An EMR is the right thing to do: leveraging its capabilities can yield positive benefits:
    - for our patients, through improved service and more accurate/complete records
    - for us as clinicians, helping us better manage clinical information and streamline some of our clinical work
    - for our practice, through improved patient scheduling, charge capture, and analysis

- Even forewarned, there will be a "learning curve" for adapting to an EMR. In the Clinical Heart Center that period was about 1-2 months for the steepest part.

- Keys to enhance likelihood of success
    - Physician and nurse involvement before beginning EMR use:
        - Workflow redesign
        - Specialty-specific order sets
        - Preference and "favorite" lists
    - Physician and nurse involvement after starting EMR use:
        - "Tune" all of the above

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